

MULTIMEDIA



UNIVERSITY

STUDENT ID NO

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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2018/2019

EOP4086 – OPTICAL SIGNAL PROCESSING
(OPE)

31 MAY 2019
9:00 – 11:00
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 5 pages with 4 Questions only.
2. Attempt **ALL** questions. Distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

Question 1

- (a) Parallel light of wavelength 656 nm is incident normally on a long narrow slit of width 0.3 mm. A lens with a focal length of 40 cm is located behind the slit to focus the diffraction pattern on a screen. Find the width of the central band of the diffraction pattern on the screen (in mm). [4 marks]
- (b) The fifth order interference maxima are missing from a diffraction pattern of a double slit. If the light wavelength is 544 nm and the width of the slit is 0.2 mm, determine:
- (i) the slit separation, and [2 marks]
 - (ii) the irradiance of the first three orders relative to zeroth-order maxima [5 marks]
- (c) Describe the changes in diffraction pattern as the number of slits increases in Fraunhofer diffraction. [3 marks]
- (d) Sketch an intensity pattern for four equally spaced slits having separation distance of 4 times the slit width (i.e. $a = 4b$). Label several points on the x-axis with the corresponding values of α and β . [5 marks]
- (e) Red light (650 nm) is incident normally on a 6 cm diffraction grating containing 3500 grooves/cm. Calculate the resolving power of the grating in the third-order spectrum. [6 marks]

Continued...

Question 2

- (a) Plane waves of monochromatic light with wavelength of 600 nm are incident on an aperture. A detector is located on axis at a distance of 20 cm from the aperture plane. Determine:

- (i) The radius of the first Fresnel half-period zone, R_1 . [3 marks]
- (ii) The number of half-period zones if the aperture is a circle of radius 1 cm. [3 marks]
- (iii) The first three focal lengths if the aperture is a zone plate with the radius of the first zone equal to R_1 . [7 marks]

- (b) Show that if one beam of a two-beam interference setup has an irradiance of N times that of the other beam, the fringes visibility is given by

$$V = \frac{2\sqrt{N}}{N+1}$$

[7 marks]

- (c) With the aid of a suitable diagram, describe the basic idea of temporal coherence of an optical signal. [5 marks]

Continued...

Question 3

- (a) With the aid of a suitable diagram, describe the use of optical lenses in performing Fourier Transform and Inverse Fourier Transform. [6 marks]
- (b) A Fourier transform spectrometer operates in the wavelength range of 4400 - 400 nm. The total path difference is 2.78 mm. Determine:
- (i) its resolution in wavenumber [2 marks]
 - (ii) the number of data points needed over the scan to avoid aliasing within this range [2 marks]
 - (iii) the scan rate if one run is completed in 30 seconds [2 marks]
- (c) State the convolution theorem in Fourier optics. By applying the theorem, show that the Fourier Transform of a triangular pulse is a sinc² function. Include an illustration in your explanation. [7 marks]
- (d) Show that

$$\Im\{f(x) \cos K_0 x\} = \frac{[F(K - K_0) + F(K + K_0)]}{2}$$

and that

$$\Im\{f(x) \sin K_0 x\} = \frac{[F(K + K_0) - F(K - K_0)]}{2i}$$

[6 marks]

Continued...

Question 4

- (a) With the aid of a suitable diagram, describe the working principle of a recording hologram. [7 marks]
- (b) As a theoretical limit, one bit of information can be stored in each λ^3 of a volume hologram. Calculate the storage capacity of 1 mm³ of volume hologram at a wavelength of 492 nm and a refractive index of 1.30. [4 marks]
- (c) Suppose a hologram is to be made of a moving object using a 1-ns laser pulse at a wavelength of 633 nm. What is the permissible speed such that the object does not move more than $\frac{\lambda}{10}$ during the exposure? [4 marks]
- (d) During the construction of a hologram, a beam splitter is selected that makes the amplitude of the reference beam eight times of the signal beam at the emulsion. What is the maximum ratio of beam irradiances there? [4 marks]
- (e) Describe the holographic endoscope, including internal and external recording endoscope. [6 marks]

End of paper.